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Needs Analysis for the Development of a STEM-Based Chemistry E-Module: Students' Attitude toward STEM and Challenges in Chemistry Learning

Analisis Keperluan untuk Pembangunan E-Modul Kimia berasaskan STEM: Sikap Pelajar terhadap STEM dan Cabaran dalam Pembelajaran Kimia

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ABSTRACT - The government aspired to achieve a 60:40 ratio of students in Science, Technology, Engineering, and Mathematics (STEM) over Arts (Malaysia Education Blueprint 2013-2025). However, the Ministry of Education is still concerned about the declining interest in STEM subjects, which is why this goal has not been achieved. A needs analysis was conducted to identify whether developing a STEM-based e-module is necessary and to determine which Chemistry topics should be focused on. A total of 32 Form 4 Chemistry students from a secondary school in Kluang, Johor, are participating in this preliminary study. Two questionnaires were distributed to the respondents to investigate the students' attitude toward STEM, and the challenges students face in learning Chemistry. The results showed three primary problems: a lack of 21st-century skills integration, insufficient classroom time for Chemistry learning, and limited access to useful learning materials. Furthermore, it was determined that the Acids, Bases, and Salts topic was the most challenging in the Form 4 Chemistry syllabus. Based on these findings, developing a STEM-based e-module focusing on this topic is crucial to improve students' achievement and fostering creative thinking skills.

ABSTRAK - Kerajaan bercita-cita untuk mencapai 60:40 nisbah pelajar dalam Sain, Teknologi, Kejuruteraan, dan Matematik (STEM) berbanding Seni (Pelan Pembangunan Pendidikan Malaysia 2013-2025). Namun, Kementerian Pendidikan Malaysia masih bimbang tentang penurunan minat dalam subjek STEM yang menjadi salah satu sebab mengapa matlamat ini belum tercapai. Analisis keperluan telah dijalankan untuk mengenal pasti sama ada pembangunan e-module berasaskan STEM adalah perlu dan juga menentukan topik-topik Kimia yang harus diberikan tumpuan. Sejumlah 32 pelajar Kimia Tingkatan 4 dari sebuah sekolah menengah di Kluang, Johor telah melibatkan diri dalam analisis keperluan ini. Dua soal selidik telah diedarkan kepada responden untuk menyiasat sikap pelajar terhadap STEM dan cabaran yang dihadapi pelajar dalam pembelajaran Kimia. Keputusan menunjukkan tiga masalah utama: kekurangan integrasi kemahiran abad ke-21, masa kelas yang tidak mencukupi untuk pembelajaran Kimia, dan akses terhad kepada bahan pembelajaran yang berguna. Tambahan pula, didapati bahawa topik Asid, Bes dan Garam adalah yang

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paling mencabar dalam sukatan pelajaran Kimia Tingkatan 4. Berdasarkan dapatan ini, pembangunan e-modul berasaskan STEM yang memfokuskan topik ini adalah penting untuk meningkatkan pencapaian pelajar dan memupuk kemahiran berfikir kreatif.

Kata kunci: E-modul berasaskan STEM; Asid, bes dan garam; Sikap terhadap STEM, Cabaran dalam Pembelajaran kimia

INTRODUCTION

Education is crucial for developing a scientific, progressive, innovative, and visionary community while also leveraging the latest technological advancements. The national science curriculum seeks to enhance scientific literacy and higher-order thinking skills among students, along with the ability to utilize scientific knowledge for making decisions and tackling real-world problems. Additionally, it aims to strengthen and reinforce students' knowledge and skills in Science, Technology, Engineering, and Mathematics (STEM) (Bahagian Pembangunan Kurikulum, 2018). The Malaysia Education Blueprint (MEB) 2013-2025 seeks to continuously improve the education system to provide holistic education for students, enabling them to compete on a global scale (Yahaya & Lajium, 2020). MEB introduced the revised Secondary Curriculum, referred to as Kurikulum Standard Sekolah Menengah (KSSM), in 2017 and enhanced STEM education. KSSM emphasizes the principles of 21st-century learning, which features educators acting as facilitators in student-centred learning. Malaysia is undergoing a period of change in its education system, focusing more on student-centred teaching and learning.

As part of the 2050 National Transformation (TN50) initiative, Malaysia is undertaking a comprehensive reform of its STEM education to elevate the nation into the top 20 worldwide in areas such as economics, citizen welfare, and creativity and innovation. Through STEM education, students are afforded opportunities to cultivate essential skills, including their problem-solving skills, creativity, critical thinking, independent thinking, communication skills, and digital literacy (Jajuri et al., 2025; Karupaiah & Saleh, 2025). The KSSM Chemistry curriculum is designed to foster scientifically literate students by providing learning experiences that encompass the comprehension of Chemistry concepts, skill development, the application of diverse strategies, and the integration of scientific attitudes and values. Furthermore, it emphasizes understanding the societal impacts of scientific and technological advancements (Bahagian Pembangunan Kurikulum, 2018). It is important to build various thinking skills among students, particularly critical and creative thinking skills. The introduction of more Higher Order Thinking Skills (HOTS) questions and challenges is instrumental in motivating students to refine their critical and creative thinking skills.

Since technology has impacted every part of our lives, it has a significant impact on our way of life today. To provide high-quality teaching and learning, educators need to be prepared with technical knowledge, pedagogy, and skills as educational technology advances (Wahid, 2019). Due to the constant advancements in technology, education has had to adjust to new teaching techniques. One of the most recent developments in classrooms is the use of web-based modules known as e-modules. Traditional classroom teaching and learning do not provide an instant learning environment, quick evaluation, and greater engagement (Karupaiah & Saleh, 2025). According to Yuliani et al. (2021), the interactive module is intended to complement conventional textbooks and other learning materials. According to Osman and Lee (2014), e-modules actively encourage students in self-learning, whereas traditional learning modules are primarily printed materials with little interaction. This study intends to develop a STEM-based e-module that focuses on the salt topic to address these challenges. This innovative tool aims to improve students' learning experiences by combining STEM principles with interactive and self-paced learning features. However, the needs analysis conducted as the initial phase of Design and Development Research is the exclusive focus of this paper.

LITERATURE REVIEW

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STEM Education

The implementation and integration of STEM education are growing rapidly in global education. STEM is a curriculum based on the idea of educating students in four specific fields, namely science, technology, engineering, and mathematics. The purpose of integrating STEM is to enhance the development of technology and the country. The Malaysia Education Blueprint 2013-2025 (MEB) is one of the policies that support STEM education in Malaysia. The Ministry of Education (MOE) ensures that students are equipped with the necessary skills to face the real-world challenges that are experiencing a revolution with the application of STEM. The STEM approach is being used to address the issue of students' low achievement in Science and Mathematics subjects (Surdi et al., 2025; Utina, 2020). Challenges in STEM education include declining student achievement in the Trends in International Mathematics and Science Study (TIMSS) and the Program for International Student Assessment (PISA), as well as the difficulty of STEM topics and students' enthusiasm for STEM. STEM education is not learning the knowledge of four fields in fragments. Still, the combination of the content of the four fields may help students think creatively and innovatively to compete in the future [Ministry of Education Malaysia (MOE), 2016].

STEM refers to educational policies and curriculum choices in Malaysia that aim to improve students' competitiveness in science and technology. The MEB 2013-2025 is a significant document, as it includes a section on methods to enhance science and mathematics achievement among Malaysian students. MEB 2013-2025 (MOE 2016) has implemented reforms in STEM education, which are divided into three phases. The first phase (2013-2015) aims to enhance STEM education quality by upgrading the curriculum, implementing standardized testing, and providing teacher training, as well as introducing blended learning methods. In the second phase (2016-2020), camping and collaborations are used to increase community interest and awareness in STEM. The third phase (2021-2025) involves evaluating the success of the first two phases' initiatives, as well as formulating plans for new initiatives and programs.

Roehrig et al. (2021) defined integrated STEM education as an effort to combine one or more of the four disciplines of science, technology, engineering, and mathematics into a single class, unit, or lesson that is based on connections between the subjects and real-world problems. Integrated STEM education is an approach to teaching STEM content across two or more STEM domains to enhance student learning (Kelley & Knowles, 2016). There are eight important principles of a quality STEM integrated environment, namely (1) engage with a personally meaningful and motivating context; (2) participate in an engineering design task with a compelling purpose that involves problem-solving skills and ties to context; (3) learn from failure and have the opportunity to redesign; (4) learn appropriate standards-based mathematics and/or science content; (5) explore content with student-centred, research-based pedagogies; (6) participate in teamwork and communication skills; (7) use evidence-based reasoning to integrate engineering with mathematics and/or science; and (8) engage in engineering design throughout the unit (Walker et al., 2018).

The Ministry of Education (MOE) emphasizes teaching methods that promote problem-solving, critical thinking, and creativity, which align well with STEM education. The Malaysian curriculum, Kurikulum Standard Sekolah Rendah (KSSR) and Kurikulum Standard Sekolah Menengah (KSSM) 2017 revision, encourages the integration of STEM elements across many subjects. STEM education aims to equip students with the 4C skills needed to thrive in the modern workforce, such as communication, collaboration, critical thinking, and creative thinking.

STEM-Based Learning in Chemistry Education

Chemistry education is a combination of educational ideas and chemistry. Chemistry is a subject that studies matter and the changes that occur within it. It is often cited by most students as a subject that makes it difficult to achieve a high score in examinations and hard to comprehend the concepts (Rahim & Lee, 2021; Sanjiwani et al., 2020; Uce & Ceyhan, 2019). However, many students still find it difficult to understand and follow chemistry lessons (Utina, 2020). Abstract concepts require a high level of understanding, causing many students to lose interest and develop a negative perception of chemistry (Rahim & Lee, 2021; Sanjiwani et al., 2020). This shows that the Chemistry learning material is more abstract. Students need to clearly understand concepts, not just memorize them, as this requires a high level of imagination (Rahim & Lee, 2021). Beyond a low level of conceptual understanding among

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students, teaching methods employed by teachers also contribute to the difficulty that students face in comprehending Chemistry (Rahim & Lee, 2021).

The STEM approach in education aims to prepare students to be competitive and ready to work in their respective fields of expertise. A STEM-based learning approach aims to develop students' logical thinking, problem-solving skills, and technological proficiency (Utina, 2020). However, several studies are implementing the STEM approach in Chemistry Education (Panggabean et al., 2023; Rahmawatia et al., 2020; Sutoyo et al., 2019; Utina, 2020). A study of Utina (2020) found that using a STEM project-based learning (STEM PBL) Science-based approach significantly improved the learning outcomes of students in understanding the concept of chemical bonds. In Rahmawatia et al.'s (2020) study, a STEM perspective was used in conjunction with a project-based learning (PBL) approach to provide opportunities for students to develop their chemical literacy. The results of this study indicated that integrated STEM PBL in chemistry learning stimulated the affective aspects of developing chemical literacy and brought students to a deeper conceptual understanding through their experience of practicing what had been previously learned only from textbooks. This shows that students were able to understand the chemistry concept through hands-on experiments.

In addition, Panggabean et al. (2023) developed General Chemistry teaching materials (books) on stoichiometry concepts using the Inquiry-based learning (IBL) STEM model based on chemical literacy. The research findings showed that the increase in students' Lower Order Thinking skills (LOTS) and Higher Order Thinking skills (HOTS) abilities is also evidenced by increased student learning outcomes before and after utilizing General Chemistry teaching materials on stoichiometry concepts using the resulting chemical literacy-based IBL STEM model. Sutoyo et al. (2019) conducted a study on the effectiveness of the guided inquiry model integrated with STEM to enhance the students' critical thinking skills. The researchers developed a chemistry learning device for thermochemistry topics using the 4-D model. The result of this study is implementation of a guided inquiry model integrated with STEM was effective in increasing the students' critical thinking skills on thermochemistry topics.

Numerous studies have explored the implementation of STEM-based learning in chemistry classrooms. These studies have shown promising results in terms of student engagement, critical thinking skills, and problem-solving abilities.

Salt Topic

Salt is considered a difficult concept for Form 4 students under the Learning Area of 6.0 Acid, Base, and Salt in the Kurikulum Standard Sekolah Menengah (KSSM) Chemistry (Bahagian Pembangunan Kurikulum, 2018). Students need to master several facts and concepts related to the Content Standard (CS) of salt. There are four Content Standards of salts, namely 6.8 Salts, crystals and their uses in daily life, 6.9 Preparation of salts, 6.10 Effect of heat on salts, and 6.11 Qualitative analysis (Bahagian Pembangunan Kurikulum, 2018).

The concept of salt in the Form 4 Chemistry curriculum is reportedly challenging due to students' limited understanding of chemistry concepts and chemical reactions (Osman & Lay, 2020). The study conducted by Napes and Sharif (2022) was to identify the problems faced by students and teachers in mastering the salt preparation CS, and to identify the need to develop a Game-Based Learning (GBL) tool for the CS. They found that the highest percentage of students and teachers agreed that the topic of salt was difficult. The difficulties faced by students in learning about salt, such as memorizing a large number of facts, can be overcome by extracting important information and presenting it in a clear and engaging format, such as models, images, and diagrams.

The CS of salts is a subtopic that involves abstract concepts, memorization, analysis, and a deep understanding of the process or material used (Doraiseriyan & Damanhuri, 2021; Doraiseriyan, 2022; Ramli & Lee, 2023). Therefore, effective teaching and learning methods are needed to address students' difficulties in preparing soluble and insoluble salts. Several teaching methods have been identified for the teaching and learning of salt CS. Azman and Sharif (2023) developed a salt e-module for the CS of salt preparation. They identified the usability of the developed e-module in terms of design constructs, accessibility, and interest. In conclusion, the developed salt e-module can serve as valuable teaching material for trainee teachers to support the delivery of the salt CS during teaching practice. Additionally, this module can enhance self-directed learning. There is a noticeable gap in research on

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using STEM-based e-modules to teach this topic. Hence, this study aims to fill this gap by developing a STEM-based e-module to make learning about salt CS more engaging for students.

Creative Thinking Skills

The Partnership for 21st Century Skills (P21) (2007) identified creative thinking, critical thinking, collaboration, and communication as among the 21st-century learning skills. Creative thinking is defined as a process by which people generate new ideas (Ernawati et al., 2019; Putri et al., 2023), identify problems to solve (Moma, 2017), and can provide confidence and enhance academic achievement (Ocon, 2012). Creative thinking skills in science learning can open new perspectives for students to give answers to scientific problems (Karupaiah & Saleh, 2025; Sumarni & Kadarwati, 2020). According to Sugiyanto et al. (2018), the indicators of creative thinking skills introduced by Guilford consist of fluency (generating ideas during the creative process), flexibility (generating a variety of concepts and categories), originality (the uniqueness of ideas), and elaboration (the addition of detailed information). All these indicators enhance students' creativity and problem-solving abilities, thereby improving learning outcomes (Fahmi & Jumadi, 2023). Wiyarsi et al. (2018) stated that in chemistry learning, students need creative thinking skills, which are essential because creative thinking is useful for comprehending various aspects, such as chemical representations. Students' creative thinking skills will not develop on their own; nevertheless, they will develop successfully if the teacher deliberately encourages students' thinking potential and manages them in a planned manner with good learning planning (Sumarni & Kadarwati, 2020).

RESEARCH PROBLEM

The main reason Chemistry is a difficult subject is that a lot of its topic depends on or are connected to the structure of matter (Kausar et al., 2022). Students have assumed that Chemistry subjects are very challenging to learn and difficult to relate to our daily lives because Chemistry is also a complex and abstract science (Sanjiwani et al., 2020). Chemistry can be challenging due to its nature and the methods used by teachers and students to understand it. Salt is one of the most challenging and difficult topics since it requires students to understand the concepts and memorize the facts (Napes & Sharif, 2022). This topic involves a lot of theories, such as types of salts and their preparation, stoichiometric calculations in chemical equations, and qualitative analysis, which consists of various tests to identify the presence of cations and anions (Osman & Lee, 2014).

There are difficulties in teaching Chemistry because fewer students are interested in STEM-related subjects (Adam, 2024). According to a Ministry of Education study, 45.73% of students were enrolled in the STEM stream in 2023, which is a very low percentage. The declining number of Malaysian students pursuing the science stream can be attributed to their anxiety and lack of confidence in pursuing the STEM field because they believe science courses have a more difficult syllabus than other courses (Ismail et al., 2019). The Prime Minister is concerned about the declining interest in STEM subjects in schools, emphasizing the urgent need for initiatives to increase students' interest in STEM subjects.

Creative thinking is defined by the Programme for International Student Assessment (PISA) as the ability to generate, evaluate, and improve ideas to produce original and effective solutions, advance knowledge, and create impact expressions of imagination (OECD, 2024). The average across Organization for Economic Co-operation and Development (OECD) countries was 78%, whereas only 54% of Malaysian students achieved at least a baseline proficiency in creative thinking (Level 3). According to a study by Jamal et al. (2020), Chemistry students in the Melaka Tengah district had low levels of creativity, namely fluency, flexibility, originality, and elaboration which indicates that they are less inventive when it comes to solving problems in the real world. These findings highlight the need to enhance creative thinking skills in Malaysian Chemistry education to better prepare them for challenging and real-world situations.

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However, the availability of STEM-based e-modules in the field of Chemistry was one of the limitations of previous studies. Thus, the needs analysis seeks to identify the specific requirements for STEM-based e-modules among Form 4 Chemistry students. It is hoped that the STEM-based e-module will successfully address their learning needs and challenges effectively.

RESEARCH OBJECTIVES

1. To identify the Form 4 students' attitude toward Science, Technology, Engineering, and Mathematics (STEM) in the context of Chemistry learning.
2. To examine Chemistry students' access to and use of digital learning resources.
3. To identify the challenges faced by students in learning Chemistry as a basis for developing a STEM-based e-module.
4. To determine the required features for developing a STEM-based Chemistry e-module.

METHODOLOGY

Research Design

This needs analysis was a survey study that aimed to determine the need for developing a STEM-based e-module based on the perceptions and attitudes of chemistry students toward STEM. Most previous researchers (Nilyani & Ratnawulan, 2023; Ramli & Tajudin, 2021; Yulis & Oktariani, 2024) employed questionnaires in the needs analysis phase of their studies. Therefore, the survey design using questionnaires is suitable for identifying students' attitudes toward STEM and their perception of chemistry learning.

Research Participants

A total of 32 Chemistry Form 4 students (15 male and 17 female) from one of the secondary schools in the Kluang district participated as respondents in this survey.

Instrument

Two questionnaires used were the Students' Attitude toward STEM and the Needs Analysis Questionnaire. The Students' Attitude toward STEM Questionnaire was used to study the attitudes of chemistry students toward STEM learning. The needs analysis questionnaire aimed to identify the problems faced by students in learning Chemistry and assess the need to design an e-module to improve Chemistry students' achievement and creative thinking skills. The questionnaires were adapted from studies conducted by Leong et al. (2020), Suprapto (2016), and Fern and Matore (2020). The questionnaires are divided into several parts, and summaries are shown in Tables 1 and 2. A five-point Likert scale was used to determine the level of agreement on the questionnaire items.

Table 1: Item Distribution of Students' Attitude toward STEM Questionnaire

Parts	Constructs	Number of items	Source
A	Demographic Profile	2	
B	Students' attitudes toward STEM learning		Suprapto (2016)
	i. Science (S)	6	Fern and Matore (2020)
	ii. Mathematics (M)	6	
	iii. Technology and Engineering (TE)	6	
	iv. Science, Technology, Engineering, and Mathematics (STEM)	7	

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Table 2: Item Distribution of Needs Analysis Questionnaire

Parts	Constructs	Number of items	Source
A	Demographic profile	1	-
B	Digital learning resources	4	-
C	Challenges faced in learning Chemistry	4	-
D	Features of the e-module	10	Leong et al. (2020)

Content validity testing was performed on these questionnaires before the pilot study. The three lecturers with an educational background checked the content and format of the questionnaires. They rated the items on a scale of 1 to 4, representing a ranking from 'not relevant' to 'highly relevant'. The items in the questionnaires were refined based on the suggestions and comments provided by the experts. The Content Validity Index (CVI) value of the Students' Attitudes toward STEM Questionnaire was recorded as 1.00. On the other hand, the CVI value of the Needs Analysis Questionnaire was recorded as 0.89, meeting the standards set by Polit and Beck (2006). Both questionnaires were then piloted, and their reliability indices were assessed using Cronbach's alpha, which were reported as 0.941 and 0.945, respectively, indicating very high internal consistency (Ahmad et al., 2024).

Data Analysis Method

The needs analysis phase includes the process of identifying and evaluating the needs or factors to be studied as a step in determining the results to be achieved (McKillip, 1987). In addition, this phase is also very important because the researcher needs to identify the research questions that are used to design the product that will be developed in the study (Jamil & Noh, 2020). The objective of this needs study is to identify the need for the development of a STEM-based e-module based on students' attitudes toward STEM learning and their perception of the challenges they faced during chemistry learning. In this study, descriptive analysis was used to analyse the data by reporting the frequency, percentage, mean, and standard deviation. To interpret the level of mean values, the mean score range by Fern and Matore (2020) was referred to Table 3.

Table 3: Mean Scores Interpretation

Mean Score	Interpretation
3.67 - 5.00	High
2.67 - 3.66	Moderate
1.00 - 2.66	Low

Source: Fern and Matore (2020)

RESULTS AND DISCUSSION

A descriptive analysis (frequency, percentage, mean, and standard deviation) was used to answer the research questions. The findings of this needs analysis will conclude whether there is a need to develop a STEM-based e-module for the Form 4 chemistry students.

Students' Attitude toward STEM

Based on the demographic information of the respondents, all of them take Additional Mathematics, Chemistry, and Physics as STEM elective subjects in the school. Twenty-five respondents (78.13%) took Biology, while 7 respondents (21.88%) took Design as their STEM elective subjects in the school. The students' attitudes toward STEM were described according to the domains. Table 4 shows the analysis of students' answers to the given questionnaire. The STEM domain has the highest mean score of 3.79 (High). Mathematics with a mean score of 3.57 (Moderate), which places it in second rank. Science was in third rank with a mean score of 3.56 (Moderate). The Technology and Engineering domain has the lowest ranking with a mean score of 3.26 (Moderate). Overall, students' attitudes toward STEM implementation are at a moderate level, with a mean of 3.56 and a standard deviation is 0.48.

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These results show that STEM is the dominant preference among respondents. In the STEM domain, most respondents stated that “Science, technology, engineering, and mathematics are good for the future of our country” (item STEM6) with 4.13 (high). Hafni et al. (2020) pointed out that STEM seeks to equip students with the critical thinking skills necessary to become innovators in an evolving world. This will enable them to tackle challenges related to the Industrial Revolution 4.0. Based on the findings, students’ attitudes toward science and mathematics domains are more positive than the technology and engineering domains. This result supports the previous research (Xu & Zhou, 2022), which is that students’ science attitude and mathematics attitude positively affected 21st-century learning skills indirectly through the mediating role of technology and engineering attitude. Technology and Engineering was the least ranked by respondents, which stated that the highest mean item is “I enjoy learning by using technology” (item TE1) with a score of 3.66 (moderate), while the lowest indicator is “I believe I can be successful in a career in engineering” (item TE6) with a score of 2.84 (moderate). When students use technology in their daily lives, technology integration enables the students to gain real-world experience and increase engagement, motivation, and problem-solving skills in STEM education (Triplett, 2023). Cheng et al. (2024) pointed out that students may have more positive attitudes toward STEM and the learning environment when engineering is integrated into the curriculum.

Table 4: Students’ attitudes toward STEM

Domain	Mean	Standard Deviation	Description
Science (S)	3.56	.0986	Moderate
Mathematics (M)	3.57	.1112	Moderate
Technology and Engineering (TE)	3.26	.1463	Moderate
Science, Technology, Engineering and Mathematics (STEM)	3.79	.1183	High

Pattern of Chemistry Students’ Internet Usage in Learning Chemistry

With 32 respondents owning a smartphone, it is the most popular technological device. This indicates how widely smartphones are being used in daily life. Furthermore, 56.25% of respondents said they own a laptop. This result is comparable to Ahmad et al.’s (2019) findings that 88.7% of students owned smartphones and laptops (69.2%). A smaller percentage of respondents own computers (37.50%) and tablets (31.25%). This may reflect how computer functions are increasingly incorporated into smartphones and laptops.

Regarding the amount of time the respondents spent using the technology device for schoolwork each week, their usage pattern was divided into five categories: Never (0 times in a week), Rarely (1-2 times in a week), Sometimes (3-4 times in a week), Often (5-6 times in a week) and Always (Every day in a week). Most respondents (53.13%) use their technology devices daily, followed by 28.13% of the respondents who use technology devices three to four times a week, and 18.75% of the respondents who use their technology devices frequently or five to six times a week. This suggests that the respondents now use technology devices daily. According to the study by Electronics Hub, Malaysians use their smartphones for an average of 8 hours and 17 minutes daily, which is the 8th highest globally. After the Philippines, we now have the 2nd highest average screen time in Asia (Jamie, 2024).

Additionally, the purpose for using the web browser was also investigated and divided into four categories, which are reading notes, searching for information, visiting educational websites, and playing games. The fact that the respondents use the web browser for seeking information emphasizes how important it is as a source of resources and knowledge. The growing use of online learning platforms and resources is indicated by the fact that 53.13% of the respondents visit educational websites using a web browser. While only 40.63% of the respondents use a web browser to play online games, 46.88% of the respondents use a web browser for reading notes, which indicates that online tools are becoming more popular for notetaking and organization. The use of technology created a consistent relationship and positive involvement in digital learning, and it was valued that there were online resources available for independent learning exploration (Niraula, 2023).

Inaccurate information was the largest problem that 75.00% of the respondents encountered when using the internet for schoolwork. The social media advertisements, online game notifications, and other distractions made it more difficult for 59.38% of respondents to use the internet for schoolwork. This

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indicates the importance of finding solutions to minimize distractions and improve focus. A few 40.63% of respondents reported they had the problem of poor internet. The students struggled to participate in online activities due to inconsistent or inadequate Internet connectivity, as noted by Arumugam and Chandre (2023). Some 28.13% of the respondents felt overloaded by the abundance of information on the internet. This indicates the need for improved resources and tools for screening and organizing information. Website navigation problems are another barrier that 25.00% of respondents reported. This indicates why more user-friendly interfaces are required. Some respondents may find it difficult to access the internet because 6.25% of respondents stated that they lack devices to meet their internet needs. Only one of the respondents (3.13%) reported that it is difficult to find the notes or information according to the KSSM syllabus.

Challenges Faced by the Students in Learning Chemistry

This study also discussed some of the challenges or issues that the respondents faced in learning Chemistry. A significant percentage of respondents (46.88%) reported having limited time for Chemistry subject in school. This highlights that more effective and efficient learning methods are needed. According to 40.63% of respondents, Chemistry students reported a lack of 21st-century skills in chemistry, such as critical thinking, creativity, communication, and collaboration. This implies that developing these skills is crucial for effective learning and problem-solving in Chemistry. Learning approaches that emphasize the 21st-century skills of students are still classified as not fully applicable and difficult (Mutohhari et al., 2021). Furthermore, a lack of learning materials impacted 31.25% of respondents. There were also reports on issues with teaching methods and interactive learning in Chemistry (18.75%). This emphasizes the importance of innovative and engaging teaching approaches. Although this percentage was lower, 9.38% of respondents indicated a lack of interest in the Chemistry subject, and only one respondent (3.13%) indicated that it is not easy to adapt or memorize the topics in Chemistry. This indicates the necessity of including both visual and audio notes in the learning materials. The most challenging topic, according to 68.75% of respondents, was Acid, Base, and Salt in Form 4 Chemistry. This finding is consistent with previous studies (Hasbullah & Lee, 2024; Lai & Lee, 2022; Othman & Lee, 2024; Redzuan & Lee, 2023) in which the same topic was mentioned as the most difficult in the curriculum. This suggests that understanding concepts such as pH, neutralization, and titration may be particularly difficult for students. For this study, the researcher chose the acid, base, and salt topic to develop the STEM-based e-module.

Most respondents believed that textbooks (81.25%) and reference books (68.75%) were the primary learning materials for understanding chemistry concepts. This shows that traditional printed materials were still useful resources for learning Chemistry. Many respondents also used digital resources such as PowerPoint slides, educational videos, games, websites, and animations. These resources can provide supplementary support and engagement in Chemistry. On the other hand, fewer respondents used interactive tools such as simulations, flashcards, e-learning modules, and augmented reality. These tools can offer hands-on learning experiences and improve understanding of the chemistry concepts (Aulia & Andromeda, 2021; Hamid et al., 2021; Rahim & Lee, 2024; Wong et al., 2021).

Pen-and-paper tests (59.38%), worksheets (65.63%), and presentations (59.38%) remain the primary assessment tools used by teachers in chemistry classrooms. This shows that traditional methods were still used widely in chemistry. A rising number of teachers were enhancing their assessments with 21st-century learning activities like presentation rubrics and peer assessment rubrics. Computerized testing platforms (21.88%) and e-learning modules with embedded assessments (9.38%) were used less frequently. A personalized and interactive assessment is offered by these tools. According to 3.13% of respondents, the portfolio is an assessment tool that is used by Chemistry teachers. The use of digital assessment platforms such as Quizizz, Kahoot, Wordwall, and Massive Open Online Course (MOOC) became more popular among educators in various fields because of technology and the development of 21st-century teaching and learning techniques (Hassan, 2024; Kamarudin et al., 2020; Lim & Yunus, 2021; Rahim & Lee, 2021).

Required Features of a STEM-based e-Module on the Salt Topic

Ten items examine respondents' perceptions of the required features of an e-module to help them understand conceptual and procedural knowledge of Chemistry. The findings show that the respondents overwhelmingly concur with clear learning objectives that will guide their Chemistry learning process. According to Hassan (2024), respondents also reported the importance of learning

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objectives in the learning material, especially e-modules. With a mean score of 3.53 (SD = 0.92), the level is considered a moderate level (Jaya et al., 2021) of importance attributed to this feature. The use of technology was rated as highly important with a mean score of 4.00 (SD = 0.76). In the research conducted by Hassan (2024) and Ghani and Lee (2022), the respondents requested the use of video, animation, audio, music, online quizzes, and augmented reality Chemistry e-modules. Lok and Hamzah (2021) assert that the novelty effect that mobile devices could further increase students' interest in Chemistry learning, which encompasses a lot of abstract concepts. This statement indicates that respondents think technology can increase interest and engagement in the learning process. According to Ghani and Lee (2022), animation was perceived as a valuable tool for comprehending abstract chemistry concepts. The interpretation was high with a mean score of 3.75 (SD = 0.88) (Jaya et al., 2021), highlighting the importance of visual aids in learning. The study by Fahlevia and Muchta (2024) found that using learning media based on animation videos improved students' learning outcomes in hydrocarbon learning. Like animation, audio was considered helpful for understanding abstract concepts. The mean score of 3.44 (SD = 0.88) and moderate (Jaya et al., 2021) indicates the role of auditory explanations in enhancing comprehension. To attract students' attention during the learning process, the use of appropriate colours was very important (M = 3.66, SD = 0.79). The use of contrasting text and the concept of background colours in the interface design can improve the reader's ability (Mohamed, 2012). Respondents stated that exploratory learning activities can boost their interest and curiosity to learn Chemistry concepts. The mean score of 3.69 (SD = 0.86) indicates that hands-on and interactive learning experiences are highly regarded. According to Kibga et al. (2021), the findings show that students' curiosity gradually increased because of the focus on using hands-on activities. Students who highly engage in hands-on activities can make them feel curious about what they are learning and enable them to better connect their prior knowledge with the new knowledge (Kibga et al., 2021). A mean score of 3.41 (SD = 0.76) shows that interaction capabilities were considered important for avoiding boredom during the learning process, which indicates the need for engaging in activities within the e-module. With a mean score of 3.41 (SD = 0.76), indicating that feedback is crucial for self-assessment and learning improvement, where respondents valued feedback from assessments to evaluate their achievements. Self-assessment was perceived as helpful for mastering Chemistry knowledge (M = 3.53, SD = 0.761). The respondents in Hassan's (2024) study also support that the self-assessment in e-modules is important. Using 21st-century learning activities and approaches was crucial for understanding Chemistry concepts. A mean score of 3.47 (SD = 0.62) indicates that the e-module needs to incorporate modern learning strategies. However, the STEM-based e-module will be developed with an emphasis on all the features mentioned.

CONCLUSION

The students' attitudes toward STEM implementation are at a moderate level, with a mean of 3.56 and a standard deviation of 0.48. The findings in this needs analysis concluded that the most challenging topic in the Form 4 syllabus is Asid, Base, and Salt. Students had limited time to study Chemistry in school, and they lacked 21st-century skills like critical thinking, creativity, communication, and collaboration. They also have limited learning material in the learning of Chemistry due to the use of traditional teaching resources and assessment tools in the school. Findings also indicated that respondents are familiar with the use of digital devices in the learning process, and they requested an electronic module applying exploratory learning with features like videos, animations, interactivity, self-assessment, and 21st-century learning activities. Hence, a STEM-based e-module focusing on improving the Chemistry students' achievement and creative thinking skills will be developed to help the students in learning of the Acid, Base, and Salt topic.

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AUTHORS CONTRIBUTION

Tien Tien Lee served as the primary supervisor for this research, providing ongoing guidance, critical feedback, and detailed content reviews throughout the dissertation process. His role played an important role in shaping the structure, academic rigor, and overall direction of the study. Nur Izwani Mohd Shapri contributed by inspiring the research focus and helping to establish the basic research.

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Zainun Mustafa played an important role in checking the formatting and ensuring that documents conform to academic and submission standards. Sarathy Hari Kumar and Nilavathi Balasundram were responsible for conducting the research, site analysis, literature review, data interpretation, and final drafting of the Paper.

AVAILABILITY OF DATA AND MATERIALS

Data available on request from the authors.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

DECLARATION OF GENERATIVE AI

During the preparation of this work, the author(s) used Quillbot and ChatGPT to enhance the clarity of the writing. After using the Quillbot and ChatGPT, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

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